Shape coexistence in Kr isotopes towards *N = 60*

A Letter of Intent for SPES

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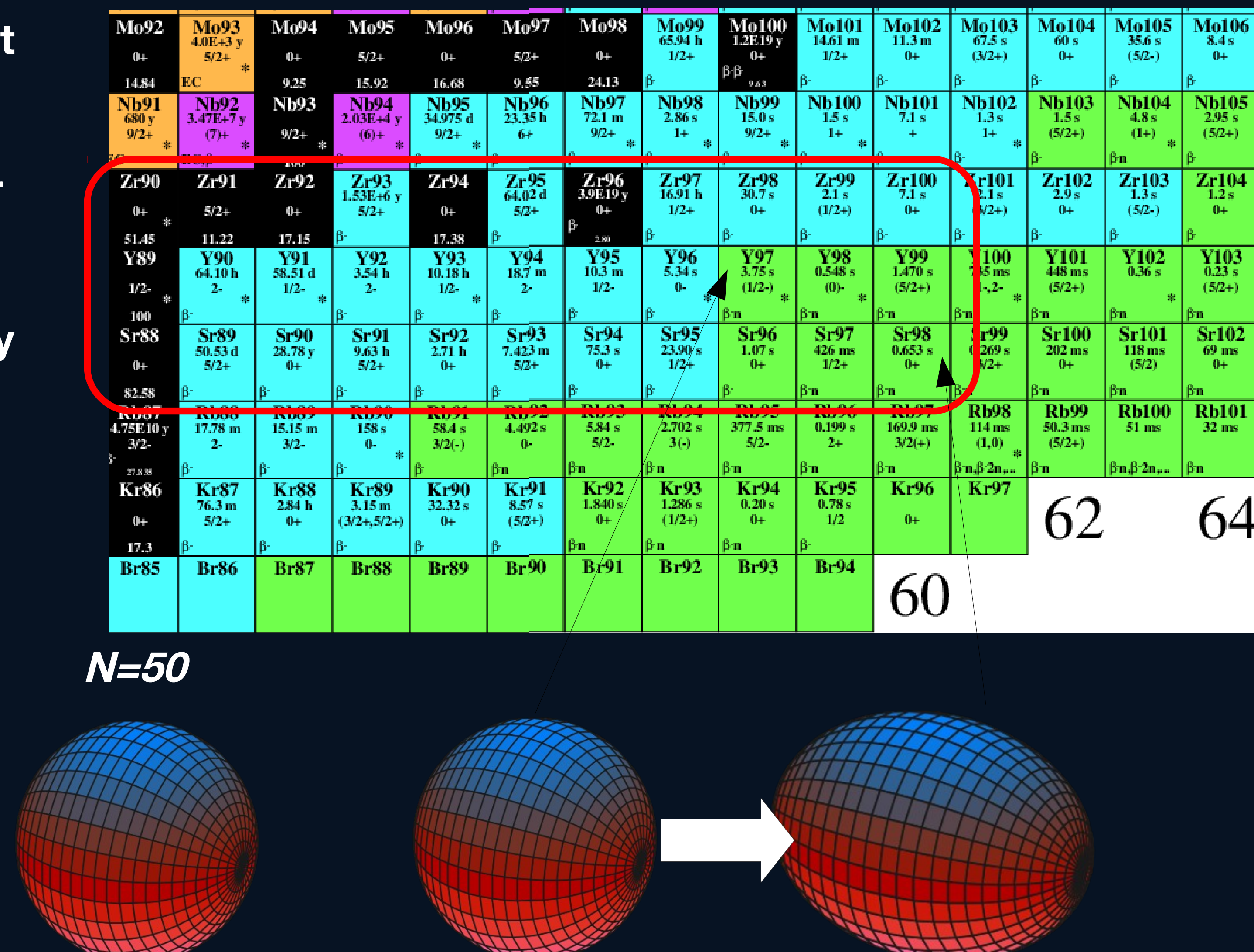
Shape evolution

Shell effects appear at N=60 producing a striking quantum phase transition in Zr and Sr isotopes, besides the smooth increase of collectivity when going towards the mid-shell.

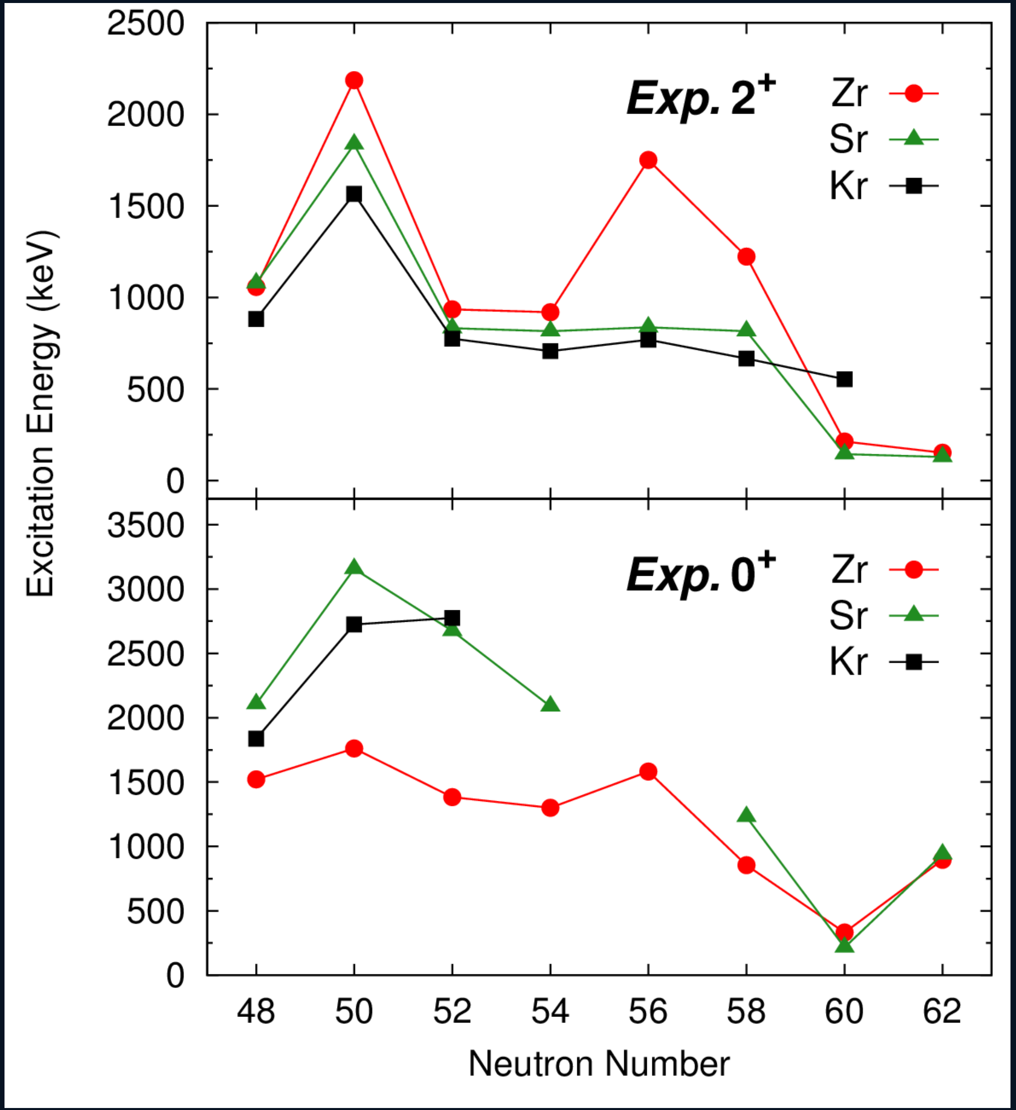


Systematics

In ^{100}Zr and ^{98}Sr (N=60) occur one of the most abrupt shape transition. From slightly spherical nuclei to highly deformed ones.

At the same time, different shapes coexist at almost degenerated excitation energies!!

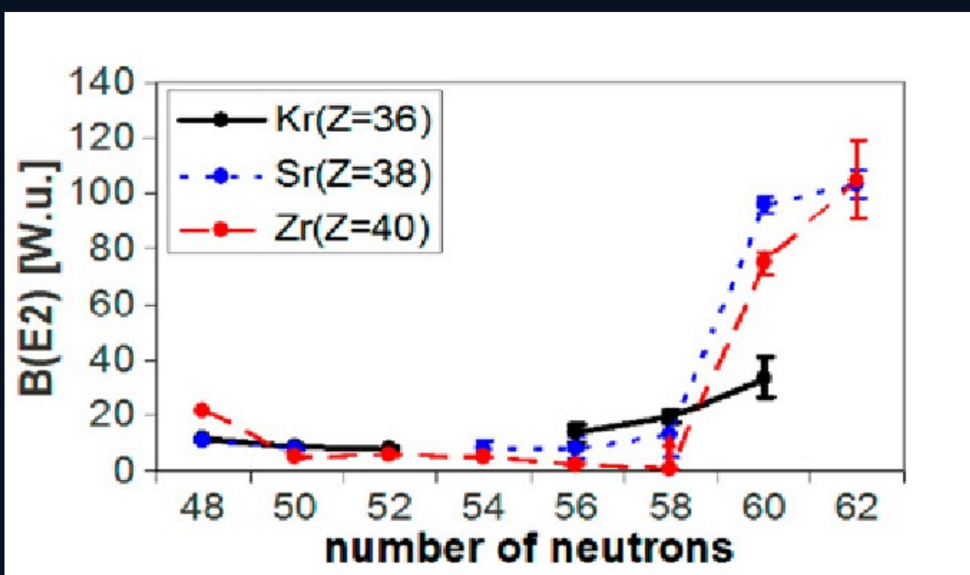
Is the shape coexistence playing an important role in the shape evolution in Zr, Sr and Kr isotopes?



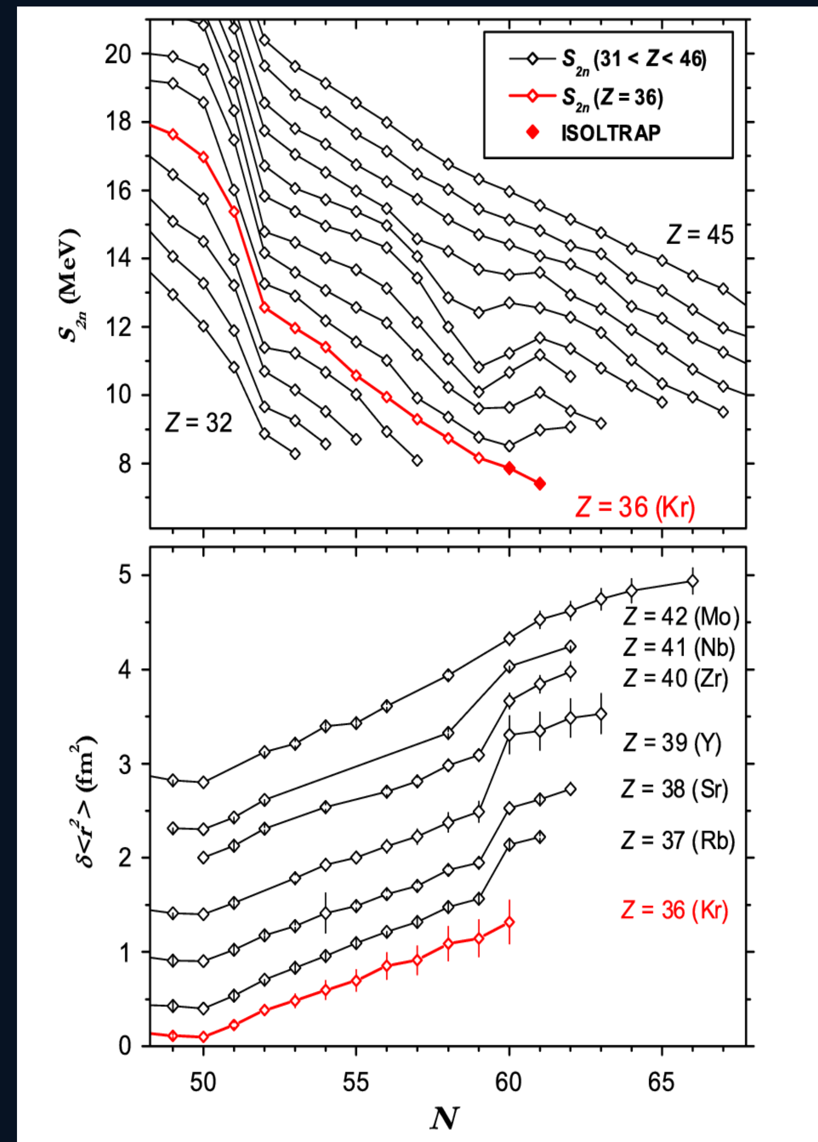
Deformation in Kr

Mass measurements and B(E2)

The Kr chain indeed, develops a very smooth transition to deformed (probably prolate) shapes.



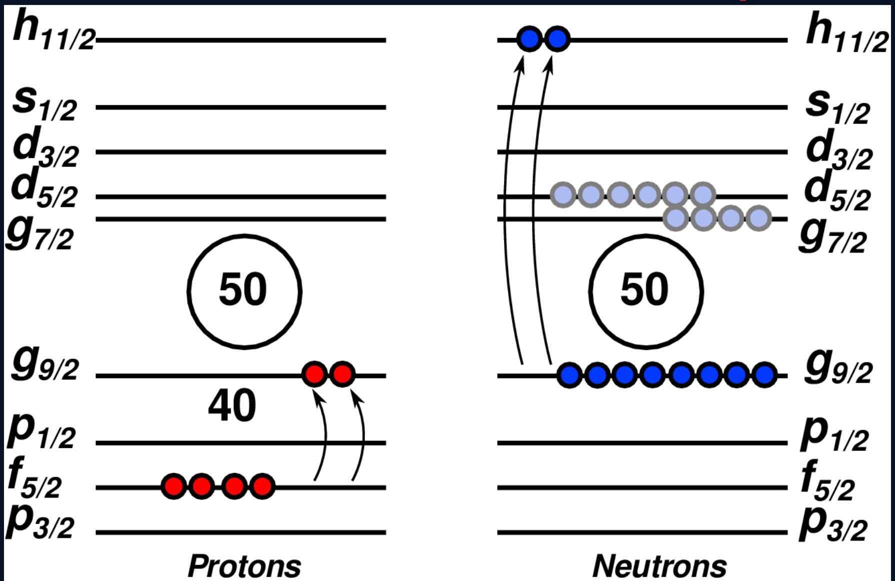
Albers et al. NIM A 899, 1 (2013)



Naimi et al. PRL 105, 032502 (2010)

Microscopic description

Prolate minimum deformation β=0.4

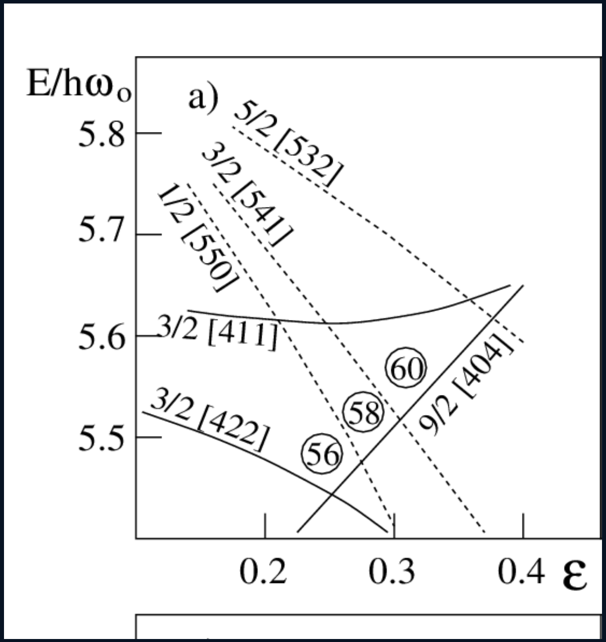


Sr (Z=38) and Zr (Z=100)

Strong correlations between the intruder proton $g_{9/2}$ and the neutron $h_{11/2}$ orbitals brings deformation in Zr and Sr at N=60.

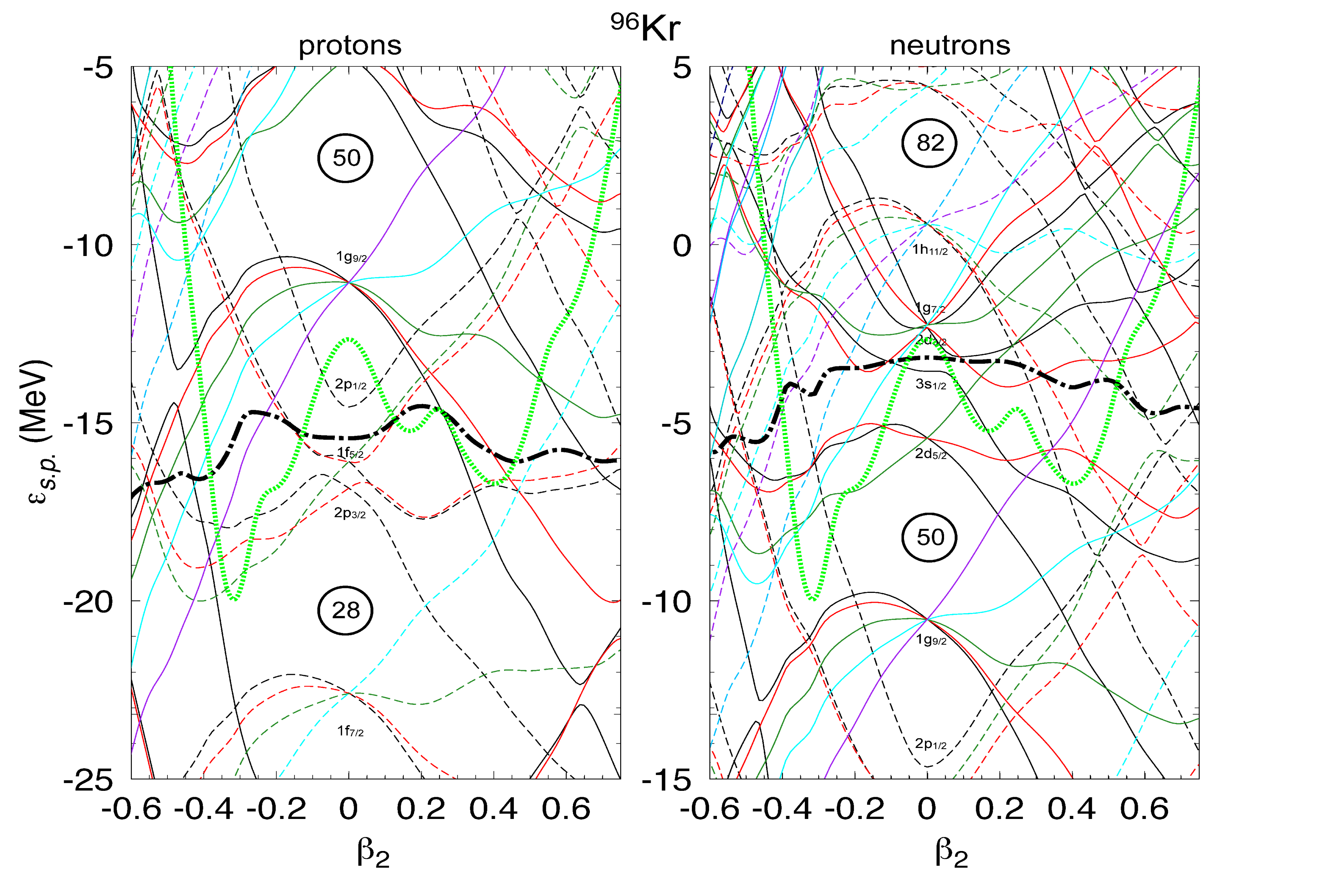
Kr (Z=36)

The occupation of the proton $g_{9/2}$ orbital is not enough to bring such rapid change in deformation to the system.

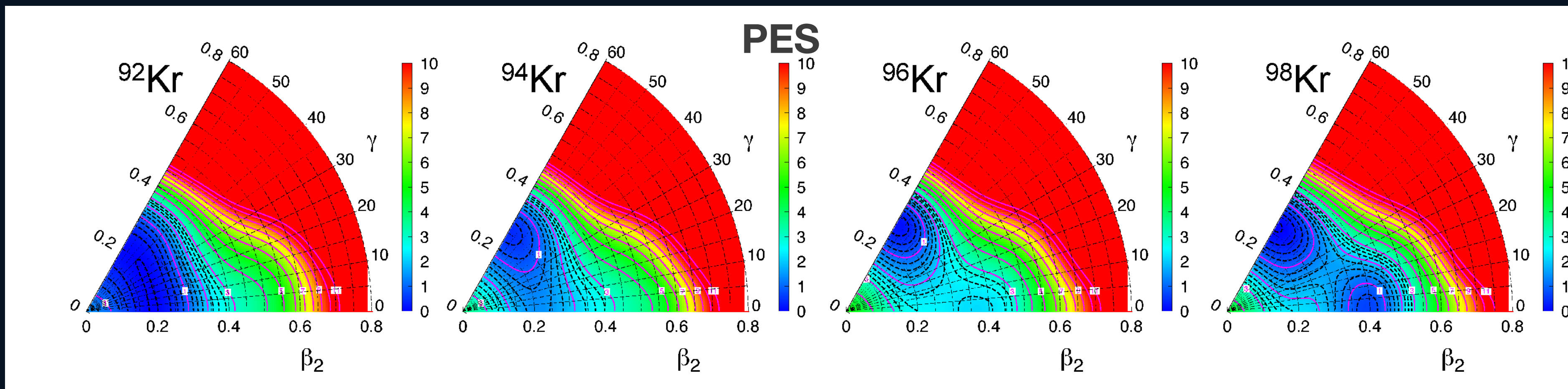


Neutron Nilsson orbitals

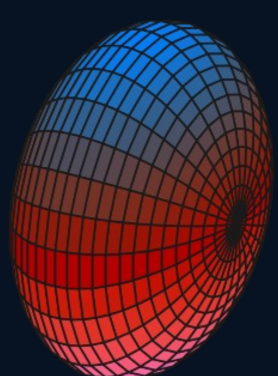
Deformed minimums on PES

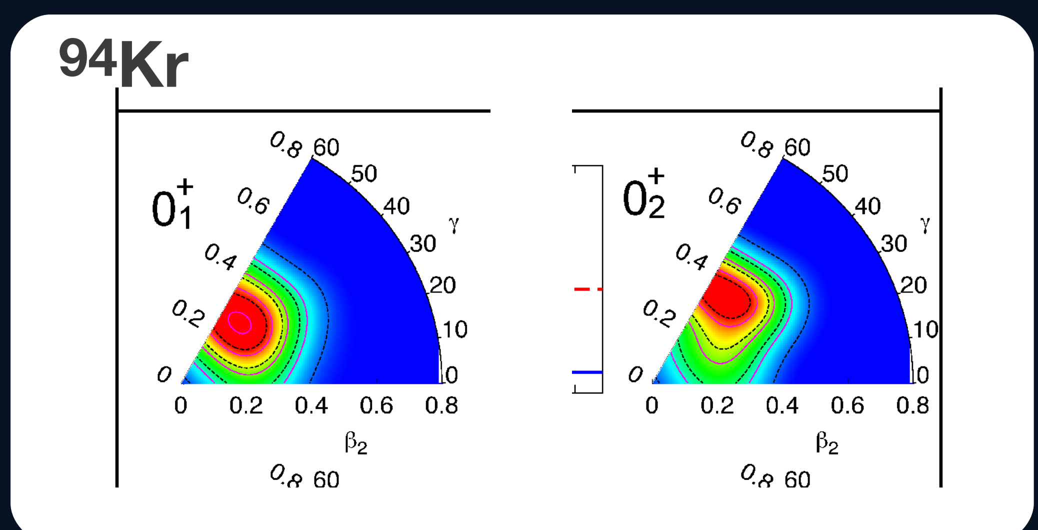


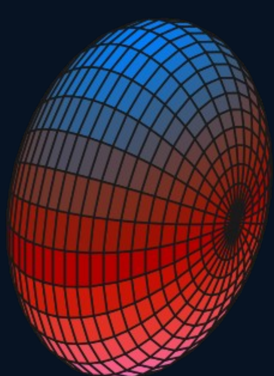
Shapes in Kr



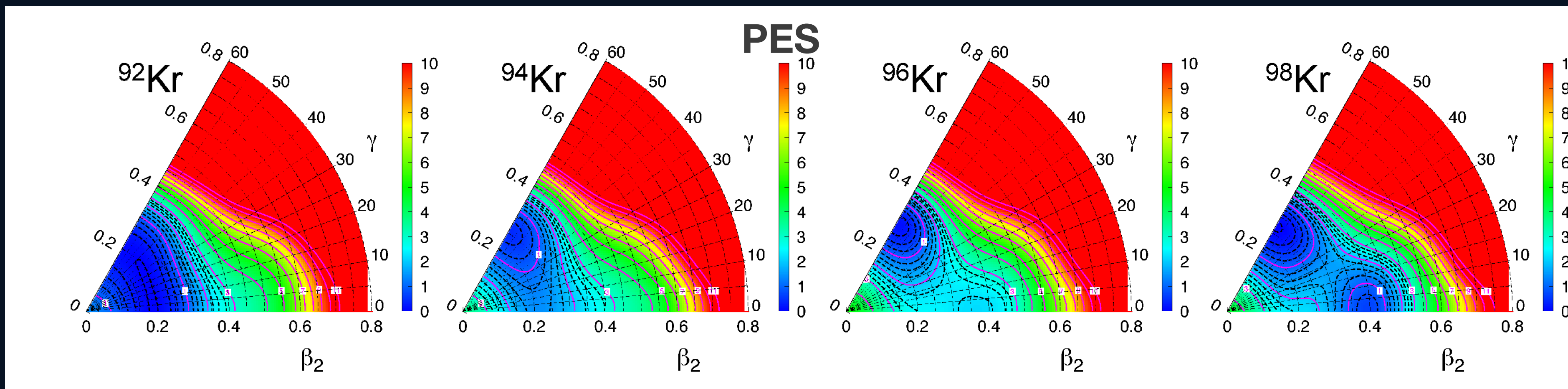
Oblate shape predominance

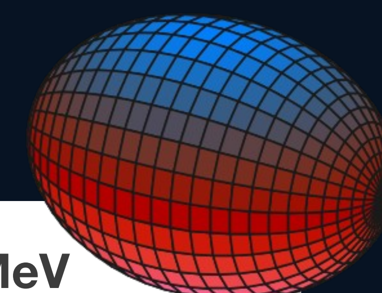






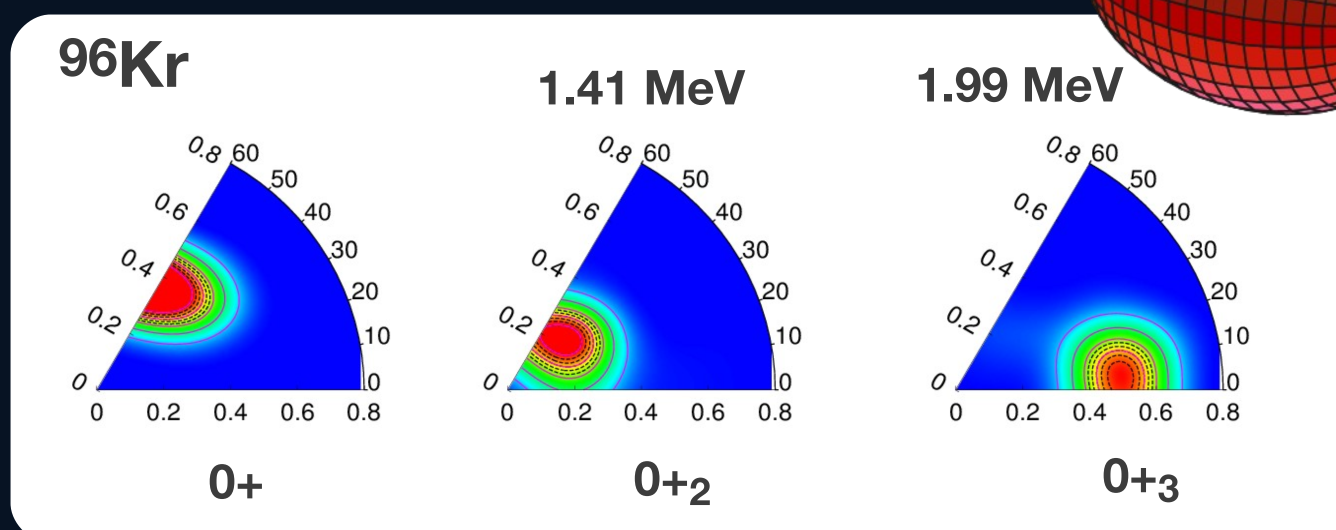
Shapes in Kr



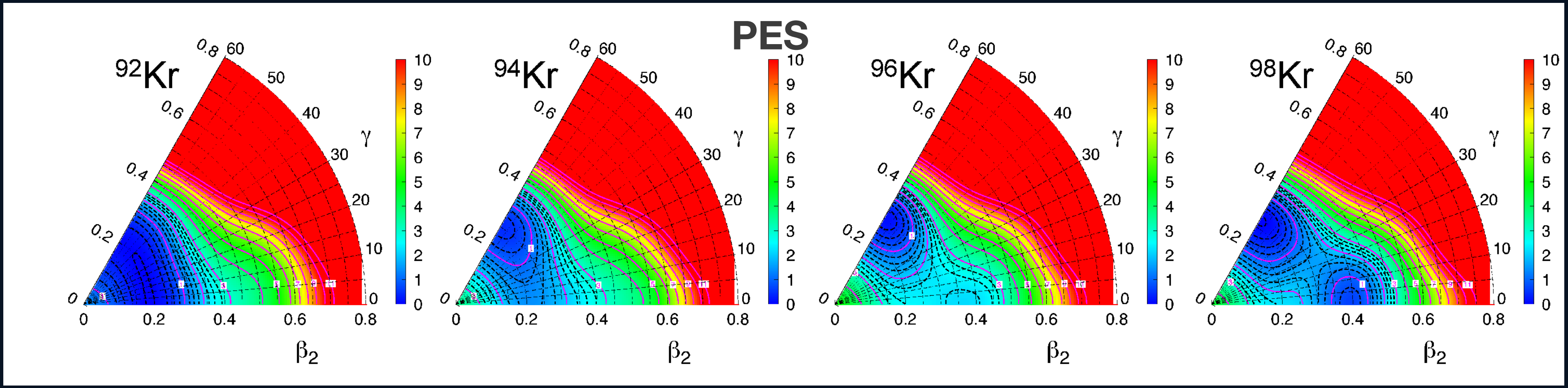


Shape transition through 3 different minima.

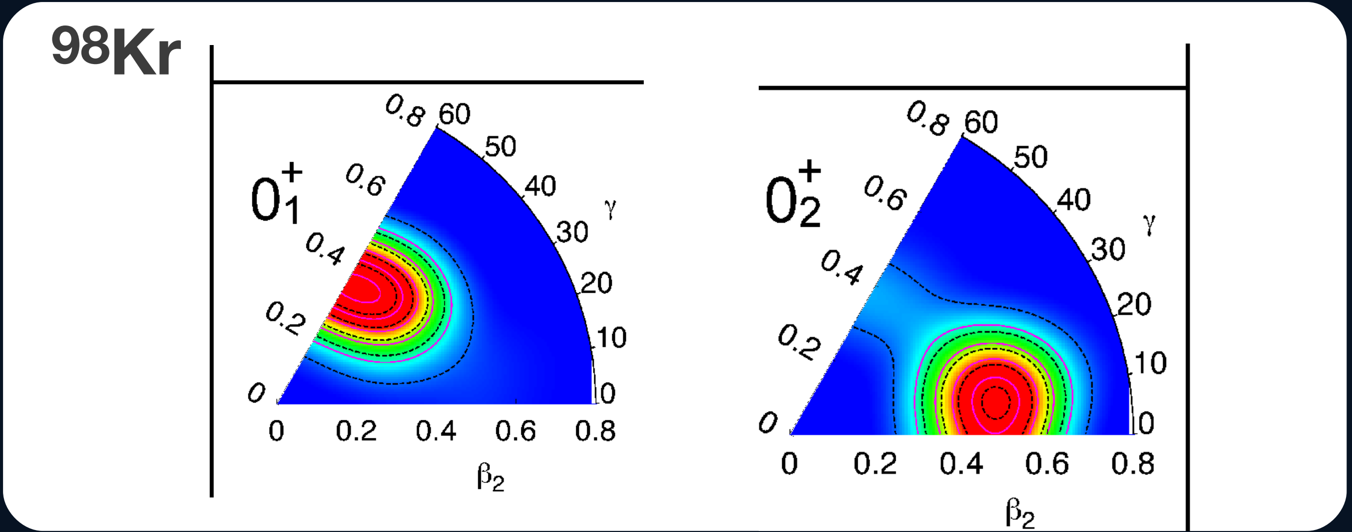
TWO oblate minima dominate the low energy spectra.



Shapes in Kr



Shape transition to prolate shape on the second 0+, at N=62



Coulex @ SPES

Coulex experiment with MINIBALL

REX-ISOLDE intensities at the secondary target

Albers et al. PRL 108, 062701 (2012)

Isotope	Year	I_{Kr} [pps]	E_{Kr} [MeV]	t_{Exp} [s]	$R_{Kr/Rb}$
^{94}Kr	2009	8×10^4	267.9	60 480	75(6)/25(3)
	2010	4×10^5	267.9	43 560	74(7)/26(4)
^{96}Kr	2009	4×10^3	273.6	32 760	43(4)/57(6)
	2010	7×10^3	273.6	59 400	46(7)/54(8)
	2011	$<5 \times 10^2$	273.6		

SPES
Estimated intensities of the Re-accelerated RIBs
C.B. eff=3- 4 %
Linac tr.=50%

Element	A	Z	N	T1/2 s	RIBs at 260KeV 1+	Re-accelerated RIBs C.B. eff=3- 4 % Linac tr.=50% particles/s	q+	Max E/A
Kr	85	36	49	3.39E+08	5,93E+08	1,19E+07	15	11,8
Kr	87	36	51	4.58E+03	2,97E+09	5,94E+07	15	11,6
Kr	88	36	52	1.02E+04	4,04E+09	8,08E+07	15	11,4
Kr	89	36	53	1.89E+02	3,99E+09	7,98E+07	15	11,2
Kr	90	36	54	3.23E+01	4,37E+09	8,74E+07	15	11,2
Kr	91	36	55	8.57E+00	2,12E+09	4,24E+07	15	11
Kr	92	36	56	1.84E+00	6,89E+08	1,38E+07	15	11
Kr	93	36	57	1.29E+00	2,28E+08	4,57E+06	15	10,8
Kr	94	36	58	2.00E-01	2,49E+07	4,99E+05	15	10,8
Kr	95	36	59	7.80E-01	1,14E+07	2,29E+05	15	10,6
Kr	96	36	60	3.20E-01	1,47E+06	2,94E+04	15	10,6
Kr	97	36	61	3.17E-01	4,84E+04	9,69E+02		

Experimental Setup

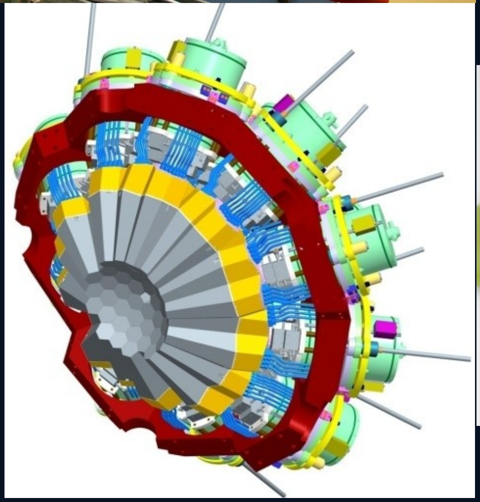
Safe Coulex experiment with thin Pt/Au secondary target

High efficiency gamma-array

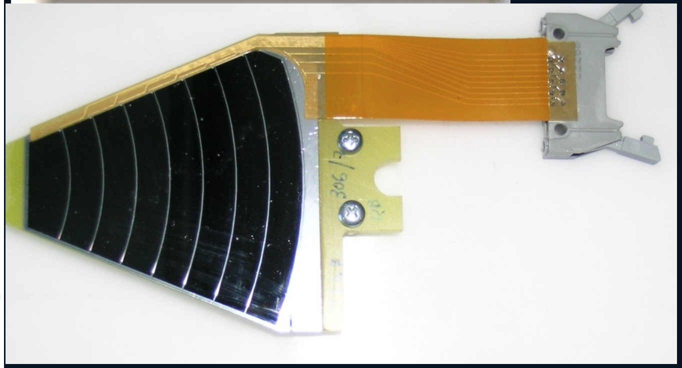
Si detectors for ion detection

GALILEO

TRACE



AGATA



SPIDER

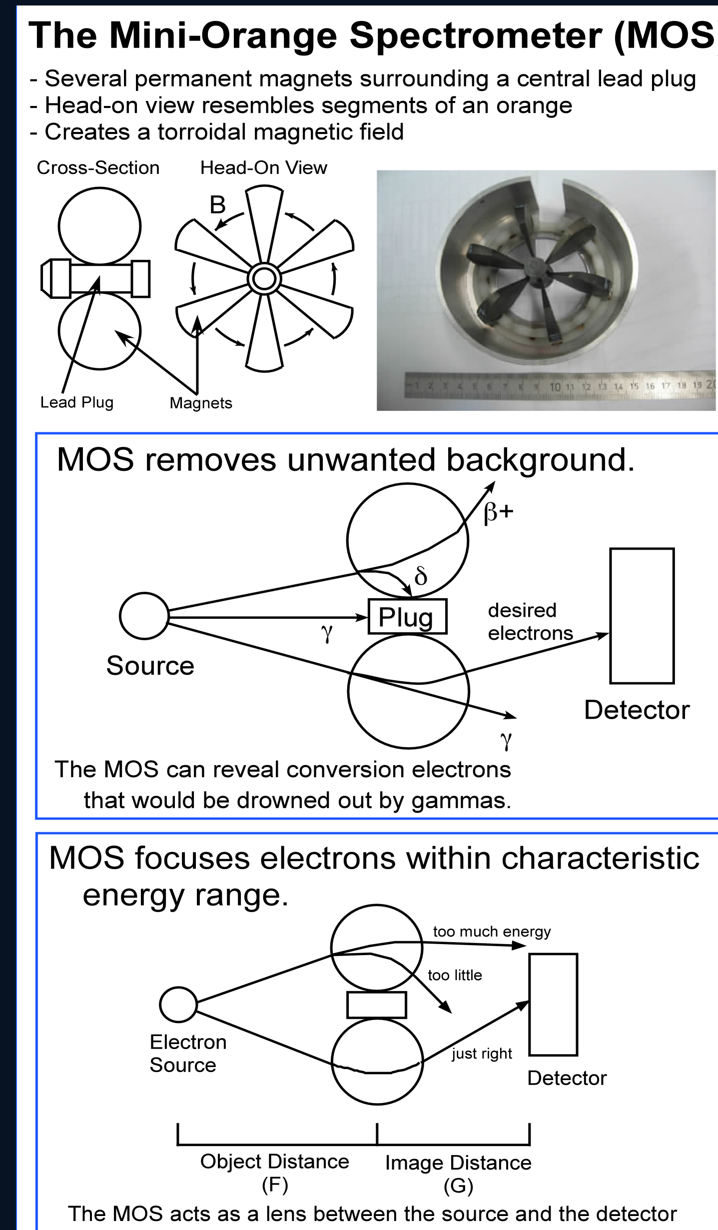
Experimental Setup

Additional ancillary detectors

Gass filled ∆E-E (Beam composition)

MINI-ORANGE device (Conversion electron E0 strengths)

Some gamma-ray detector @ beamdump



Summary

- **Safe Coulex with a RIB delivered by SPES will lead to populate the low-lying states in 96Kr and obtain transition strengths.**
- **Population of the first 0+ excited state: better understanding of the shape transition around N=60 in the Kr chain.**
- **Also, better understanding of the shape transition at N=60 for the Zr and Sr isotopes.**
- **Perfect playground for mean-field calculations.**

Collaborators

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Possible shape mixing